HYDROGEN RECHARGING SYSTEM FOR FUEL CELL HYDRIDE STORAGE RESERVOIR

TECHNICAL FIELD

This invention relates in general to fuel cells, and more particularly to a system for rapidly charging hydrogen fuel to the fuel storage container.

BACKGROUND

In recent years, nearly all electronic devices have been reduced in size and made lightweight, in particular portable electronic devices. This advancement has been made possible, in part, by the development of new battery chemistries such as nickel-metal hydride, lithium ion, zinc-air, and lithium polymer that enable larger amounts of power to be packaged in a smaller container. However, since these are secondary or rechargeable batteries, they need to be recharged upon depletion of their electrical capacity. This is typically performed by connecting the battery to a battery charger that converts alternating current (typically 110 volts AC) to a low level direct current (typically 2-12 volts DC). The charging cycle typically lasts a minimum of 1-2 hours, and more commonly 4-14 hours. Although the new batteries are a tremendous advancement over the previous generations of batteries, they still suffer from the need for sophisticated charging regimens and the slow charging rates.

Some have sought to replace electrolytic batteries with small fuel cells. Simply put, fuel cells catalytically convert a hydrogen molecule to hydrogen ions and electrons, and then extract the electrons through a membrane as electrical power, while oxidizing the hydrogen ions to H_2O and extracting the byproduct water. The tremendous advantage of fuel cells is the potential ability to provide significantly larger amounts of power in a small package (as compared to a battery). However,

the problem of how to replenish the supply of hydrogen fuel to the spent fuel cell still seeks an elegant and practical solution before widespread consumer acceptance occurs. Some have sought to use methanol as the source of hydrogen, by catalytically converting or 'reforming' the methanol using exotic schemes. At the current state of the art, fuel cells directly powered by methanol are still a laboratory curiosity, and significant technical obstacles remain to be overcome. Even with seven decades behind us since the Hindenberg disaster, consumers remain wary of hydrogen gas, and thus there is no infrastructure to provide hydrogen to refill exhausted fuel cells. Thus, even though the energy conversion portion of the fuel cell has been refined to the point where it is commercially viable for small devices, the problem of how to safely provide hydrogen to consumers in small quantities remains to be commercially implemented.

BRIEF DESCRIPTION OF THE DRAWINGS

The sole drawing figure is a schematic representation of a self-contained hydrogen recharging system for a fuel cell metal hydride storage canister in accordance with the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A self-contained hydrogen recharging system for a fuel cell metal hydride storage canister. A water reservoir provides water to an electrolyzer, where the water is converted into hydrogen gas and oxygen gas. The hydrogen gas is stored in an accumulator, and is dried either prior to or after storing. When the metal hydride storage canister is ready to be refilled, it is connected by the user to the recharging system. A heat exchanger heats the fuel cell hydride storage canister prior to transfer of the stored hydrogen gas, and then cools the fuel cell hydride storage canister during transfer of the stored hydrogen gas. The hydrogen gas stored in the

accumulator is rapidly transferred to the hydride storage canister and stowed in the canister as a metal hydride. While the specification concludes with claims defining the features of the invention that are regarded as novel, it is believed that the construction, method of operation and advantages of the invention will be better understood from a consideration of the following description in conjunction with the drawing figure.

Referring now to the single drawing figure, a self-contained hydrogen recharging system 5 for a fuel cell metal hydride storage canister consists of several elements. A vessel, container or canister 10 holds a supply of water 15 that will subsequently be converted into hydrogen and oxygen. The container 10 can, of course, assume many forms, such as an open container, a can, a capsule, a tank, a reservoir, etc. Additionally, a water supply line (not shown) connected to, for example, a municipal water source or other high purity water supply, can be substituted for the container 10. The water supply line can be permanently connected or arranged to be removably coupled. The water 15 is hydrolyzed into hydrogen and oxygen in the electrolyzer 20. Electrolysis (also known as hydrolysis) is a well known double decomposition reaction involving the splitting of water into its ions and the formation of a weak acid or base or both. This is brought about by passing a direct current through a platinum anode and a platinum cathode that are immersed in the water. The overall decomposition reaction is:

$$2H_2O \xrightarrow{\text{direct current}} 2H_2 + O_2$$

At the cathode, hydrogen ions are produced, that combine into H_2 molecules, and are collected above the surface of the water as hydrogen gas 22. At the anode, oxygen ions are likewise produced and combine into O_2 molecules 24, and are similarly collected above the surface of the water. The oxygen can either be collected

or vented to the atmosphere. In fuel cell systems that utilize pressurized oxygen as a source of oxidant (rather than ambient air) one would collect and store the oxygen in a manner similar to that used for the hydrogen. In most cases, however, the oxygen will simply be vented to the atmosphere. The hydrogen gas 22 is dried by passing through a dryer 26 where any residual water vapor is removed. It is important to have a dry source of hydrogen for stable fuel cell operation. The gas can be dried either prior to storage in the accumulator, or during the charging of the metal hydride canister, and can be dried through any number of schemes, but we suggest that a commercial desiccant such as silica gel or 3 Angstrom molecular sieves be used, as they are easily obtainable and easily replaceable or regenerated when exhausted. The hydrogen gas 22 (either dried or not dried) is stored in an accumulator 30. The accumulator 30 is intended to be a storage system, and as such can assume numerous configurations, such as, for example, an expandable bladder, a pressurized vessel, or a container with a piston that can store the hydrogen at or slightly above atmospheric pressure. The pressure generated at the electrolyzer 20 by the production of hydrogen gas 22 can be used to 'pump' the hydrogen gas into the accumulator 30 and store it at pressure. Of course, this pressure is limited, and if one wishes to store additional quantities of hydrogen gas, it needs to be compressed and stored at elevated pressures. This can be accomplished by incorporating a mechanical compressor into the accumulator 30. The compressor (not shown) compresses the hydrogen so that it can be stored in a rigid pressurized container. Storage of pressurized hydrogen requires requisite safety considerations, and it is assumed that the skilled reader will adhere to the well-known safety precautions in the handling of pressurized hydrogen.

When the hydride storage container 100 in the user's fuel cell becomes empty and needs to be replenished, one

connects it to the self-contained hydrogen recharging system 5 and the hydrogen gas 22 held in the accumulator 30 is rapidly transferred via a valve 62 to the hydride storage container 100. For purposes of clarity, it should be noted that the hydride storage container 100 is part of the user's fuel cell system, and can be integral to the fuel cell or it can be a removable component, such as a vessel with a quick disconnect. The hydride storage container 100 is typically filled with a material that stores the hydrogen fuel as a metal hydride, rather than as hydrogen gas. Thus, when the hydrogen gas is charged into the user's hydride storage container 100, it undergoes a chemical reaction that converts the material to a metal hydride. Those skilled in the art will appreciate that large quantities of hydrogen can be safely stored in the metal hydride form. For example, many modern electrochemical rechargeable batteries use nickel-metal hydride as the media for storing electrochemical energy, and this material is very similar to that used in the hydride storage container 100. Since the hydrogen-metal hydride reaction is exothermic (produces heat), a heat exchanger 55 is provided to remove the heat of reaction. Cooling the hydride storage container 100 during charging allows for rapid recharging. The charging time using our invention compares rather favorably to the long charging time associated with present day batteries if examined from a recharge rate standpoint. As an example, a 7-volt radio battery with 1500 milliamp-hour capacity takes approximately two hours to recharge, at a recharge rate of 5.25 watt-hours per hour. A state of the art 7 volt fuel cell system of comparable physical size to the above battery has approximately 10 times the energy capacity, providing 15,000 milliamp-hour capacity, but can be recharged using our invention in only ten (10) minutes, thereby recharging at a rate of 630 watt-hours per hour.

The heat exchanger 55 can also include a heating system. Over time and use, the material in the hydride

storage container 100 may collect contaminants and lose some hydride storage capacity, typically ranging from 10-15% loss. The material can be purified and 'refreshed' using the present invention in the following way. The heat exchanger 55 is operated in a 'heating' mode, and heats the hydride canister 100 prior to charging, allowing the release of residual hydrogen and other contaminants, while an optional vacuum pump 60 evacuates the contaminant gases through purge valve 62. Then, the hydride canister 100 is cooled and recharged as described previously above.

In an alternative embodiment, a charge meter 40 monitors and measures the amount of hydrogen gas that is transferred to the spent fuel cell canister 100. In its simplest form, the charge meter is a flow meter. In order to provide a package that is commercially viable, the entire system as described above is optionally contained in a housing 70, similar to present day desktop battery chargers, typically less than or equal to one cubic foot in volume. Thus, the safety conscious consumer can have a small, simple, effective method for rapidly recharging spent fuel cell canisters. Our invention provides recharging times for fuel cells up to 100 times faster than present day electrochemical battery charging methods. Since water and electricity are the only raw materials needed to replenish the system, our invention can be used virtually anywhere with minimal cost.

While the preferred embodiments of the invention have been illustrated and described, it will be clear that the invention is not so limited. Numerous modifications, changes, variations, substitutions and equivalents will occur to those skilled in the art without departing from the spirit and scope of the present invention as defined by the appended claims. For example, the instant invention as shown and described can also be used with other hydrogen based fuel cell storage systems, such as carbon nanofiber or nanotube storage systems, and additionally, pressurized hydrogen storage vessels.